Creating and maintaining an effective interdisciplinary research team

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Abstract

Any one area of interdisciplinary research is ephemeral: it either fails, or succeeds in solving a particular problem, or it expands until it develops into a new orthodoxy. As a style of tackling intractable problems it has unique value, but the costs can be high — both to individuals and to managers of R&D.

It is the perceived costs that raise difficulties for managers wishing to implement interdisciplinary research. For success, the situation requiring an interdisciplinary approach must be so perceived by all involved and they must believe that the requirement will last for some years.

Because it is a high risk activity where those taking part may find difficulty in returning to the mainstream of research, the rewards must be higher. The total benefits must be thought worthwhile both for those paying for the research, and for those who carry it out.

The present paper discusses when interdisciplinary research should be adopted, how to make it work, and how to cope with some problems it creates.

INTRODUCTION

In the literature there are many papers that discuss interdisciplinary research, and raise issues that the author has experienced in 25 years of running interdisciplinary research projects in industry. However, academic studies tend to take a snapshot of situations, and most industrial managers are allowed only a short experience of the power and frustration inherent in managing interdisciplinary research.

The present paper considers interdisciplinary research (IDR) as being one of several possible approaches to meeting the needs of an organisation, and of satisfying those seeking a certain career experience.

DISCUSSION

In the technical world there are three main kinds of protagonist, the paymaster, the organiser, and the doer.

The paymaster would prefer not have to devote resources to an activity that is sometimes connected only indirectly to the success of his aims. However, if he is persuaded that technical work is necessary, he will need doers, and he may need an organiser. The paymaster may be an individual or an organisation, and in the public or private sector.

The organiser needs a paymaster who believes that the proposed work is of sufficient complexity to justify putting an organiser onto the payroll. He also needs to believe that the work will lead to a continuation of worthwhile employment.

The doer must believe that the paymaster is serious in his intent to complete the proposed project, and that success in that project will enhance his reputation sufficiently to ensure continuity of worthwhile employment.

Of these people, only the doer has a vested interest in the continuance of technical employment through his personal investment in specialised training.

This simple description is the basis of the vast technical edifice seen in advanced industrialised societies, and is relevant to a discussion of interdisciplinary research because it corresponds to the 'survival level' of an R&D organisation. It is invoked whenever substantial change is feared, and especially when there are financial difficulties.

Who then are these people with the labels 'paymaster', 'organiser' and 'doer'? Identify-

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ing them can be easy in the case of an industrial company, and very difficult in a university or government setting. For example, a multinational company with a central technical facility may have an overseas subsidiary in the paymaster role, represented by the production or marketing director. The organiser may be the manager of the central facility, and the doer may be the leader of an engineering group.

This common situation is one around which many questions hover: For example was the work commissioned

to solve a technical problem?
to justify delay?
to stave off critical actions by the holding company?
to share the blame for a situation that has developed?

These questions interact with considerations of feasibilty, cost, timescale, loss of alternative opportunities and perceived value of the work.

In government-sponsored work the situation may be similar, but appears from the outside to be much more diffuse. Allocations are made by the paymaster to achieve broad objectives. Committees take the role of organiser to distribute grants among appropriate individuals and departments in universities and the government service, and to monitor the outcomes.

Applications from doers align research possibilities to match committee guidelines. Criteria of excellence are very difficult to establish, partly because the purpose to be served has a social, political, and economic context that may change before project completion. Criteria of academic rather than functional excellence tend to dominate.

Despite their obvious differences, both public and private sector efforts can be identified with seven principal technical purposes (Table 1). The balance between those purposes is chosen to suit circumstances, aims, and time-horizon of the supporting paymaster. Most of these purposes can be found to some degree in organisations with hope for their future, although not all those purposes will be realised within a formal R&D department.

Of the technical purposes listed in Table 1, only research and pathfinding activities are likely to benefit from interdisciplinary research (IDR). The other purposes are served quite satisfactorily with multidisciplinary research (or development) as and when required. But in many organisations both research and pathfinding also proceed without IDR, so when is it wanted and why?

Table 1 Purposes and Key Characteristics of Technical Effort

Purpose	Key Characteristic
Education	Instruction and experience of achieving
Manufacture	Predictable output at controlled cost
Technical service	Firefighting Timely use of present knowledge
Product development	*Circular incremental development, mostly using standard techniques and assessment methods.
Development	Network of planned actions to achieve a goal, where the basic feasibility of that goal is already established, but the cost effective delivery is not.
Research	Objectives are known, feasibility unknown.
Pathfinding	Objectives unknown, effort based on faith in ways of exploring possible futures. External control and formal planning are inappropriate. Management style is entrepreneurial.

* This style is common where multi-attribute goals have to be achieved, for example in the food, drink, fragrances, and cigarette industries

Interdisciplinary research is research in-between disciplines. It begins to create a new specialisation which, if successful, may lead to the establishment of a new discipline that is a respectable field of endeavour in its own right. It is a response to a technical opportunity or to an increasingly complex set of problems.

Multidisciplinary research (MDR) brings together a mixture of disciplines to solve certain problems that are jointly within their competence. Its structure is decided by management and progress is managed by comparing predicted with actual outcomes for given resource utilisations. The individuals on the project team speak with the authority of their specialisation, and the project leader has to manage the incompatibilities of attitude and achievement. There can be strong group pressures preventing individuals straying from their areas of

proven professional competence. MDR is a delicate negotiating process where the integrity of each discipline and its prestige take priority over the ephemeral cooperation in a joint project. At the end of the project, none are likely to have the prestige to cross disciplinary boundaries and speak with authority. An example of this occurred when attempting to determine the inhalation toxicology of cigarette smoke. A biologist, an aerosol physicist, and a chemist were the key personnel on the MDR team. The members of the team learnt something of each other's skills and experimental approaches, but at the end of the work none could have commanded respect as an authority in either of the co-operating disciplines.

Paradoxically, MDR seems to be a forerunner of IDR in an organisation. Sooner or later, the MDR team will not have an expert available in a needed discipline. For example, a group developing environmental chambers did not have an adequate expertise to test human response to the stress caused by tasks performed in unusual temperatures and atmospheres. A chemist took an interest: he operated ECG and EEG machines, and designed vigilance test equipment. His results were presented to an international conference and gained him much credit with experts in this field.

Another example of an encouraged development is chemometrics which is beginning to emerge as a new discipline. Long before the term 'chemometrics' was coined, an individual known to the author was being asked to produce 'commercially useful information' from a mass of seemingly unrelated chemical analyses. After improving practical techniques to reduce variance in the raw data, he applied multidimensional scaling programmes. Not a large step perhaps. But from there he devised new statistical treatments that gained him the respect of professional statisticians, and that enabled him to identify both the competitor's sources of raw materials, and his processing methods.

If staff are encouraged to think and operate in such a way, commercial problems can inspire many unpredictable interdisciplinary developments. The key is people with low energy-barriers to entering a new field. Such people rapidly develop an ethos of their own based on opportunity-seeking rather than risk-avoidance. Once an organisation has had experience of high-flyers operating in this way, it can choose to encourage career development along these lines.

As IDR people are given management experience, they tend to adopt a similar approach to other matters. One successful project involved devising technologies to be compatible with overseas cultural and social norms, thereby minimising future industrial disruption in the factories.

The choice of IDR is both a business and a personal decision. IDR is not appropriate for projects where standard methods and organisational forms are producing good results, because IDR is expensive, especially in the early stages. Indicators that it is desirable for pathfinding and research are listed in Table 2.

If pathfinding is highly desirable as a corporate strategy to cope with a changing environment, then IDR is essential. Pathfinding activities are also desirable when a paymaster wishes to see innovation becoming part of the corporate culture. It will throw up many blank leads, but it is more likely to produce a successful outcome than other strategies.

Table 2 Indicators of the Need for IDR in an Organisation

Strong Indicators
Successful competitors depend on IDR.
Problems have arisen that require a continuing close co-operation between different disciplines.
Unconstrained customers go elsewhere for advice and products.
Organisation has a long term commitment to survival. Major challenges with a novel technical dimension occur every few years.
Company profits are large and stable, and products have a technical basis.
Flexible commercial situations are not matched by a flexible responsiveness from R&D.
Terms of trade, and nature of competition are becoming adverse.
Weak Indicators
Decreasing acceptance of outputs by technically advanced customers.
Innovations are constrained by religious, social, and political views.
Decreasing ROI from investment in R&D
Frozen functionalism in R&D.
Company operations constrained by need for permissions from third parties.

There is natural affinity between pathfinders and the top management of an enterprise: each is seeking routes towards a successful future. Effective directors of technology, marketing, and finance share thinking processes which are largely unconstrained by the conventional wisdoms and procedures.

Thus the two protagonists who may have a genuine need for IDR are the paymaster and the doer: the paymaster, because he sees that existing paradigms of the business and its purposes are becoming obsolete; the doer, because he has faith in his ideas and needs an opportunity to carve out a speciality that will provide an intellectually exciting career that might not be available from a less adventurous path.

It is rare to find an organizer who has IDR as a prime responsibility; most have a larger responsibility for more predictable matters. Consequently, if the organiser suggests that IDR is wanted, then his views and situation must be suspect. The organiser needs predictability and continuity to maximise the benefit of his skills, the last ingredient he requires is an independent-minded and successful cell within his responsibility and beyond his control.

Thus the scene is set for an interesting and complex conflict of interests. The remainder of this discussion is concerned with how the conflict may be managed as a positive-sum game where each of the protagonists may gain. The situations of each are considered in turn.

The Paymaster

The paymaster may come in three styles:

He pays, but does not direct.
He pays, and directs at the level of objectives
He pays, directs and manages the technical part of the organization.

If he merely pays, he cannot command the introduction of IDR. This is a problem for those wishing to see IDR in universities. Existing faculties compete for funding, and it is not in their interest to introduce more competition. If the funding is derived from industry, it may be withdrawn before a new discipline has become sufficiently mature to continue unaided.

If he pays, and directs at the level of objectives, IDR will take place if that is the only way his organizers can achieve those objectives. For the contractors it is a strategy of last resort.

If he deals direct with the doers, as happens in many small contracts between a university department and an industrial paymaster, then the doers may see the opportunity for IDR as a stepping stone to academic recognition within their own discipline. The IDR may be ephemeral, but can be a great success for both parties.

If he pays, directs, and manages the technical part of the organisation, then IDR becomes a real option and can be selected on its merits because both the will and the power co-exist to change the climate of technical work.

Where the paymaster has a direct responsibility for the operation of the technical function, he has to judge the nett benefit of introducing IDR. In other circumstances the task falls to the organizer who has to consider whether the organisation can accommodate IDR, and benefit sufficiently from it, to pay for the organisational stress it will cause. IDR is entrepreneurial in character, and flourishes in an informal, opportunity-seeking, atmosphere. Such an atmosphere may be quite stressful and uncongenial to the majority within the current organization, where a hierarchical structure provides the framework for a sense of self-worth for individuals.

Organisational stress from introducing IDR can be estimated by considering that stress which already exists. Manufacturing and Technical Service share a common approach in that quantity, quality, delivery and price are paramount. The organisation structure is likely to be top-down authoritarian.

Product Development and Process/Machine Development share the frustrations of awaiting deliveries from outside suppliers, and of collisions of priority for scarce resources. They have a mixed structure where top-down and bottom-up styles co-exist, often in time-slicing mode. Functional group, and project group management methods may operate as a formal matrix, although many organisations do not find the formalisms as helpful as the pragmatic application of the concepts.

Research management is involved in frequent alternations of top-down and bottom-up approaches, as research findings transform the situations and assumptions on which the top-down plans have to operate. A federal grouping of semi-autonomous specialist teams, consulted on all major projects helps to avoid re-invention and inappropriate objectives.

If such a mix of management styles already exists within an effective organisation, then the added stress of IDR ought to be manageable at reasonable cost.

The Doer

The doer has to ask himself whether he has the right temperament for IDR, how far he is likely to progress up the promotion ladder, and whether the organisation has the need for IDR at that level over the timescale in which he is seeking a career.

If he specializes in IDR, he will eventually be a person of unique skills. He will have a fairly independent position in the structure with few if any direct competitors. On the other hand, there will no safe ground to retreat to if that specialism is no longer deemed useful: his present organisation may downgrade or dismiss him, and another organisation may not require him. He will always be facing new challenges, and if he fails in any significant area, his position may be in jeopardy. He will have the stress of having to prepare for many options which may not be required. There will be no established body of literature or of precedent to uphold him in a difficult period. He may be required to enter disciplines and thought patterns for which he has no great aptitude. IDR is definitely not suitable for those who merely wish to survive on the payroll.

He must be confident in his technical abilities and, in particular, he must be confident in his ability to enter new areas of knowledge and make a contribution there with little support from a peer group. His contribution may take two forms:

> bringing his discipline to bear in areas where its skills and insights are novel; or an ability to master a new subject and contribute at the frontiers of that subject in a short time.

If he is bringing his discipline to bear in a novel area, he will fit the definition of a Bridging Scientist. His career prospects are of a rapid acceleration of promotion to a low ceiling level. He will tend to become a middle ranking generalist whose skills are well behind those of leading practitioners in the constituent disciplines.

If he can master a new discipline and illuminate the frontiers in a short time, then he is likely to transform situations in his workplace. If the opportunities exist to use his abilities, and the organisation can adapt to rapid change, then his career in the interdisciplinary area will be impressive. However, such a person is very vulnerable to a withdrawal of support or a change in the climate before his efforts have been successfully converted to worthwhile results. He could be cast aside with little to recommend him, either within the organization or outside it.

He therefore has to have faith that the demand for IDR is based on a sound analysis of the needs of the organisation, and that the management will be both supportive and ethical in their treatment of him. The problems of continuing support in a changing environment can be eased if he believes that the problem is suitable for sub-division into projects that will allow him to assist a monodisciplinary group at least once a year.

Another important factor is the social and professional climate created by his colleagues: jealousy, politicking, intolerance of uncertainty, and fear of change, are all indicato.. that the spontaneous support of colleagues, which is crucial when problems arise, may not be made available.

Finally, the doer has to have reason to believe that the organization has the commercial confidence, management talent, financial strength, and moral courage to use the results obtained, and to take new initiatives. It is not unknown for IDR to destroy some basic assumptions on which the organisation is operated. If the reaction of senior management is to close their eyes and hope that no-one else will make a similar discovery, then there is no future for IDR in that company. If the reaction is to look steadfastly into a new future where old truths have vanished, and there is confidence that the advance warning given by IDR provides time to plan for the

new situation, then the futures of both the technologist and the company are more secure.

If the climate for IDR is perceived to be unfavourable, despite overtures from the management, then individuals who are drafted into such work will decide that the IDR work will either be downgraded to multi-disciplinary cooperation with all the that that route can entail, or that they will leave the interdisciplinary teams created by management as soon as decently possible with as much personal kudos as possible.

The Organiser

The organiser's position is an interesting one. He has three options:

To co-operate with the instruction to create an IDR group.
To do that but ensure that all its output is credited to conventional function or project groups, thereby killing the motivation for IDR,
To delay in the hope that the paymaster will fade from the scene, will change his mind, or will be proved wrong in his analysis.

There are many ways of stopping a good idea, so this section concentrates on the first option where the organiser, however reluctantly, decides to do a professional job. This is is also a touchstone of likely success, because unless the organiser has a high reputation for integrity within the organisation, he will not be trusted by those who are being asked to put their careers at risk.

The peer-group of doers *need* an organiser they can trust. He has to be well-read, able to identify critical steps, able to detect faulty reasoning, and able to suggest matters that have been overlooked. Above all, he will support his staff in the corridors of power, particularly during that crucial period when capital has been spent but there is little to show for it.

His first tasks on appointment are to review the decision to adopt IDR, and to cost its introduction and continued operation within the organisation. The costs include the added complexities, the diversion of management time, the cost of lost opportunities, and the loss of efficiency while the organisation comes to terms with the new ideas. Part of that task is to estimate how long IDR will be required, and what level of activity will eventually be involved. Will it be confined within R&D, will it provide an internal consultancy service to divisions, or to the main board of directors? The answer to the question will determine the age, experience and ability that will be required for staffing the new group in the early phases.

Regardless of rank in the organisation, it is essential that those recruited shall have a very good track record for intellectual courage and moral honesty. If these people are to be signposts for the future of the company, it is worse than useless to start with those that are likely to bend to irrelevant pressures. There will be many occasions when this group will have no precedents, and no peer group to review their recommendations effectively.

Identification of suitable recruits is critical to success. The organiser is likely to find suitable staff in the upper quartile of performance in their parent discipline. Careful questioning will reveal whether they are already doing IDR even in the face of open discouragement. Other indicators are that:

they will already have shown that they can make efficient and wise use of resources and give good value for money;
they are undeterred by messy unstructured problems, and will have little resistance to learning new skills;
they are sensitive to errors, and correct them spontaneously;
they are not dogmatic;
their earlier successes were not obtained at the cost of slowing a colleague's project;
they will show curiosity about the world and possess unexpectedly deep knowledge of seemingly unrelated subjects;
they will have substantial achievements to show in leisure interests;
they will probably have a strong sense of the ridiculous.

The organiser may have to encourage people to move into the new opportunity. One essential is to provide proper funding. At least four aspects should be considered: capital for facilities, revenue for operating them, revenue to compensate for an above-average rate of obsolescence, and salaries to pay highly qualified staff. If funding is determined by company policy on return on

investment (ROI), the new venture is likely to be throttled at birth. During the start-up phase, it is appropriate for individual projects to be required to meet only 30% of standard ROI or even less to allow for the delay between investment and achievement, and for the learning process.

When the group has matured the full ROI should be expected from its project portfolio as a whole, possibly defined by a moving average as returns are likely to be subject to peaks and troughs. It is advantageous if the person managing IDR is personally answerable for the benefits obtained from its use.

If the company demands rigorous conformity with financial ratios, an alternative way to achieve the average ROI required by organisational policy from the technical department as a whole is for the department to demand a higher figure for its less risky work such as Technical Service, and to specify a lower figure for IDR and other high risk areas.

If the company has a good salary structure, it will allow for an above average performance in IDR but, to maintain the enthusiasm of the participants in IDR, there must be continuing positive advantages. The first should come from the interest in the work, the second should come from enhanced security: the risk can be high for someone who has worked on IDR projects for many years. Employees in the 35–55 age band are likely to have responsibilities that do not permit taking risks with their earning power. If the company wants to avoid having judgments coloured by personal circumstance, there is an argument for adding extra security which may take the form of an extended notice period of between two and five years, and added years in the pension fund.

The organiser will have to integrate a different kind of career progression with the more orthodox route of

Section-leader
Group-leader
Division-manager
Research director

People involved in IDR may well be attracted to:

managing technologies for economic performance;
carrying out technical audits;
being internal consultants to divisions and overseas subsidiaries;
becoming a personal assistant to a director who has responsibility for policy formulation.

In such roles they would benefit from interactions with government policy groups, the media, politicians, religious and cultural leaders overseas, and experience of analyzing the economics of commercial operations. To active minds, such a career could be most attractive.

Unification of such an apparently privileged group with the rest of the technical departments could give trouble. One management technique that is helpful, is to develop a 'government' and 'loyal opposition' structure in the technical function. The loyal opposition is recruited from managers at each stage of their career, they are taken out of busy-work, given an office and told to act as a consultant, or to plan for the future of their discipline or their old department.

Managers in the loyal opposition do not know whether their recommendations will be accepted, and if accepted, whether they or some other person will be called upon to implement the proposals. In general, IDR experience will give good training in the thought processes required. IDR people may be put back into line management for a period to provide them with man-management experience. Those that succeed in the process will be recognised as having greater ability, and in consequence will be less resented. Appointment to an IDR group can be a good training experience for younger professionals, especially if they see senior technicians in such a group achieving more than the average graduate.

Since all groups proceed by trading mutual favours, the IDR groups should be able to tax other departments for a portion of the effort of bright people, and be expected to rescue those departments when IDR owns the latest appropriate technology.

IDR is risky technically, and it often needs a major improvement in data generating technologies to put its unusual conclusions to rigorous test. One IDR group achieved a 500-fold improvement in productivity in a year, where the norm was 20%. Such achievements

are not uncommon, but can be frightening to those exposed to that degree of change. This is one reason why organisers can be reluctant to condone IDR in their fiefs.

Nevertheless, if the game is played fairly and with imagination, all participants win.

In conclusion, Interdisciplinary Research is a practical option for organisations needing to provoke discontinuities or adapt to unexpected circumstances. IDR requires time to develop to a state where it is seen to be a sound proposition for a sponsoring organisation. It therefore requires commitment from sponsors, organisers and doers, and a high level of trust between them; and this is especially important in the early stages of implementation. For the individual, the rewards are a full and satisfying career; for the organisation, the rewards are the avoidance of mistakes, the realisation of its potential, and the availability of a pool of tested talent.